IRC:SP:66-2005

# GUIDELINES FOR DESIGN OF CONTINUOUS BRIDGES

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# CONTENTS

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# GUIDELINES FOR DESIGN OF CONTINUOUS BRIDGES

## 1. INTRODUCTION

**1.1.** The Reinforced, Prestressed and Composite Concrete Committee (B-6) of the Indian Roads Congress was reconstituted in 2003 with the following personnel:

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*Corresponding Members*

Ashok Basa
C.V. Kand

**1.2.** At its first meeting on 29th April, 2003, the Committee felt that in the light of the massive construction programme that was under executionin the highway sector, it was necessary to bring out guidelines on certain topics which were not adequately covered in the existing IRC Codes and Standards. The design and construction of continuous bridges was one of the topics selected. It was decided that while highlighting the special design and detailing requirements in each case, the guidelines would be generally in line with IRC:18 and IRC:21 with additional inputs from BS:5400, EURO and AASHTO codes, wherever necessary.

**1.3.** The initial draft of the guidelines was prepared by Shri Alok Bhowmick. The draft was discussed by the B-6 Committee at its several meetings and finalized in its meeting held on 3rd September, 2004. The draft document was approved by Bridges Specifications and Standards Committee in its meeting held on 20th December, 2004. The document was considered by IRC Council in its 173rd meeting held on 8th January, 2005 in Bangalore and approved subject to certain modifications. The required modifications were accordingly carried out by the Convenor, B-6 Committee before sending the doucument for publication.

## 2. SCOPE

The guidelines cover the analysis and design requirements for the following types of concrete bridges :

a) Continuous Bridges
b) Bridges made continuous through deck slabs.

The guidelines are applicable for the design of continuous type of bridges in reinforced concrete

or in prestressed concrete or precast girder bridges made fully continuous for superimposed loads & live load by providing in-situ concrete diaphragm at support or bridges with tied deck slabs with continuity provided using dowel bars debonded from girder at support. It shall be read in conjunction with the existing provisions in the relevant IRC Codes.

## 3. DEFINITIONS

### 3.1. Continuous Bridges

Continuous bridge is a bridge with the superstructure longitudinally continuous over intermediate supports on bearings. There are several methods of achieving the continuity in Superstructure. Fig.1 shows some of such methods.

### 3.2. Bridges made Continuous through Deck Slab

These are bridges built using girders, which are simply supported, and made continuous through cast-in-situ deck slab.

## 4. IMPACT FACTOR

For continuous bridges, the live load impact factor shall be calculated in accordance with Clause 211 of IRC:6-2000, wherein the span length to be considered shall be as under :

(i) For bridges with spans of equal effective length, the effective span length (c/c of pier).

(ii) For bridges with spans of unequal effective length, the least effective span length.

(iii) For bridges with only deck continuity, the effective span on which the load is placed.

## 5. CONTINUOUS BRIDGES

### 5.1. Analysis

**5.1.1.** Elastic method of analysis shall be used to determine the forces and deformations, taking into account all aspects of response of the structure to loads and imposed deformations.

**5.1.2.** The effects of creep and shrinkage of concrete, temperature difference and differential settlements need not be considered while checking the safety against ultimate stage failure[1] .

**5.1.3.** Secondary effects due to hyperstatic reactions of prestress shall be taken into account while analyzing the structure. For ultimate stage checks, the load factor for prestress (including the hyperstatic effects) shall be taken as 1.0 [1].

**5.1.4.** Due account shall be taken of the change in nature of the structural system and in material properties that occur during the construction sequence of a continuous bridge. The behaviour at any stage of the construction sequence shall be analyzed, duly taking into account the effect of creep redistribution.

**5.1.5.** The critical section for shear shall be as follows:

(i) When the reaction in the direction of the applied shear introduces compression into the end region of the member, sections located at a distance less than 'd' from the face of the support may be designed for the same shear as that computed at distance 'd'.

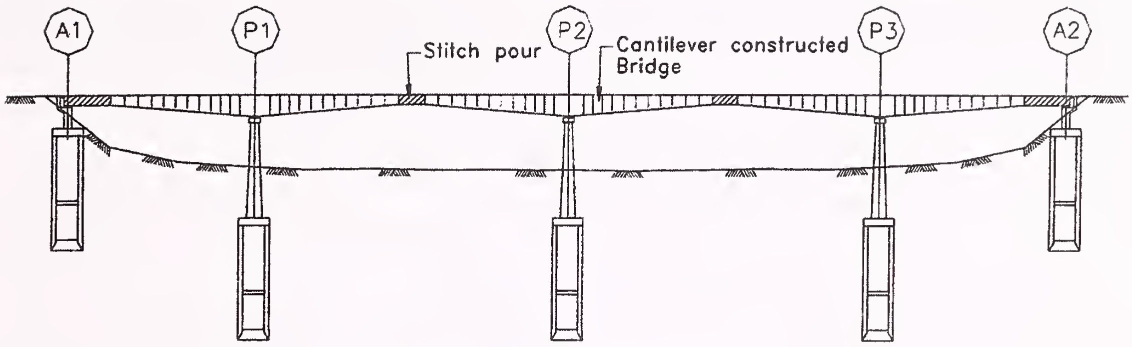
(ii) When the reaction in the direction of the applied shear introduces tension into the end region of the member, shears computed at the face of the support shall be used in the design of the member at that section.

### 5.2. Design

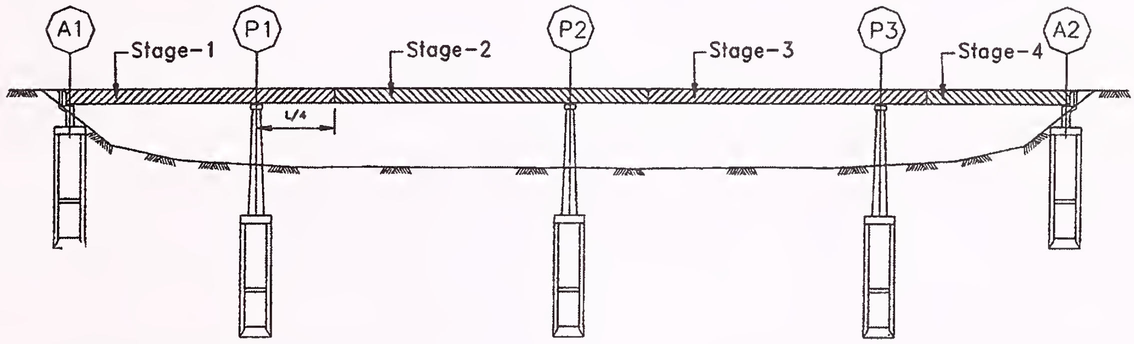
The design bending moment over an intermediate support of a continuous deck supported on bearings may be calculated by equation[2] :

$M_1$ = $(M - qa^2/8)$ or 0.9M, whichever is greater, where,

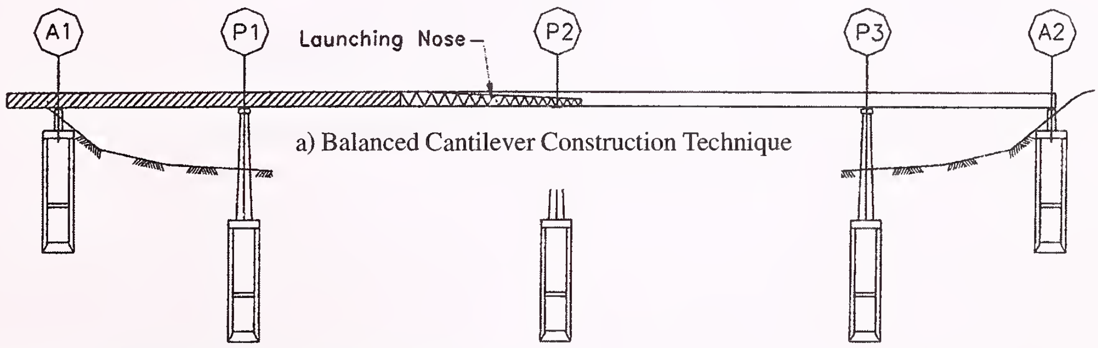
$M_1$ = Design bending moment.



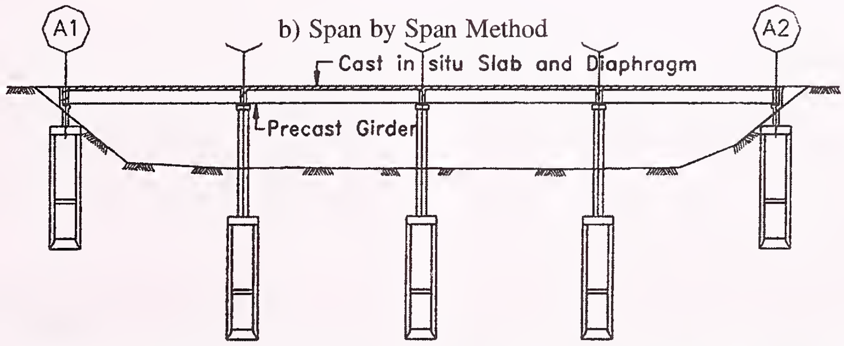

a) Balanced Cantilever Construction Technique
(Cast-in-place or Precast segmental)




b) Span by Span Method




c) Incremental Launching Method




d) Precast Girders Made continuous by in situ slab & Diaphragm
(For SIDL & LL)

Fig. 1. Methods of Achieving continuity in Bridge Deck

M = Analysed Bending moment at centerline of intermediate support.

q = R/a

R = Reaction at the intermediate support

a = Width of Bearing in the direction of span (Refer Fig. 2).

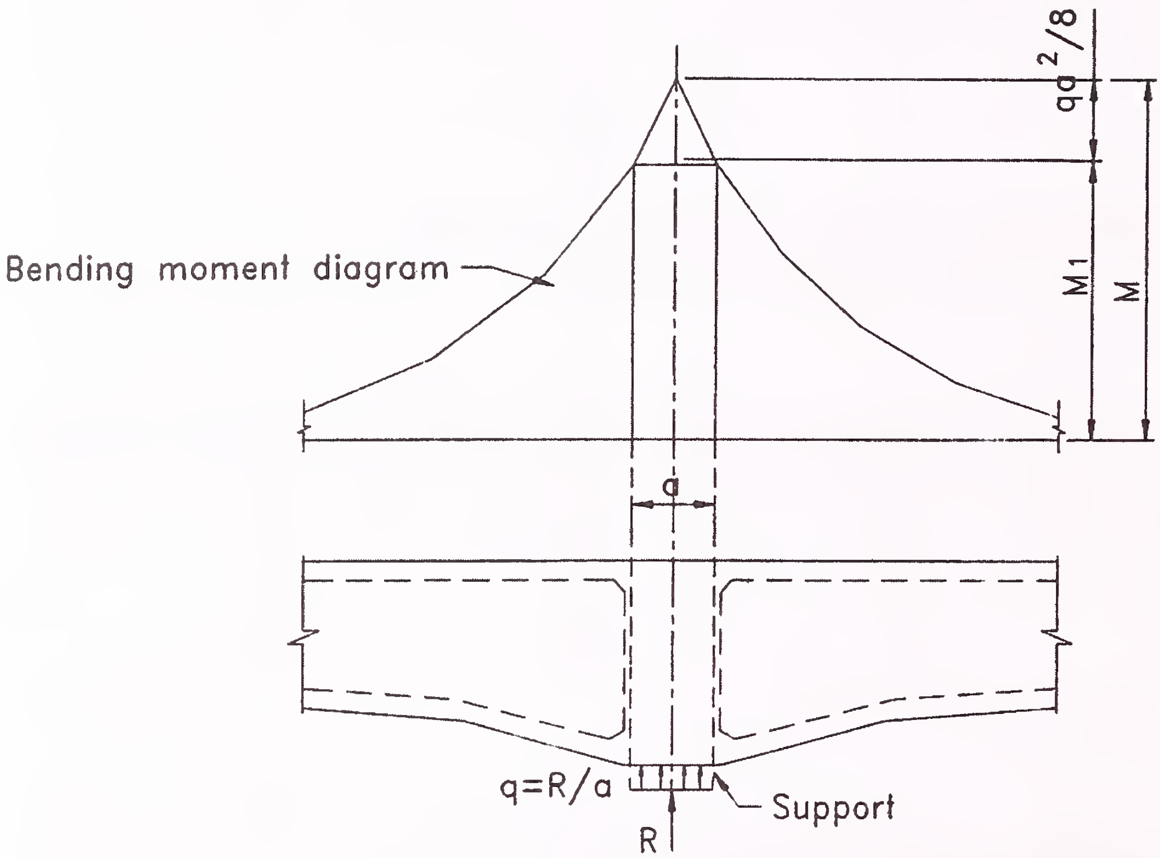



Fig. 2. Design Bending Moment over an Intermediate Support

**5.3. Dimensioning & Detailing**

**5.3.1. Bearing Layout & Movements:** The selection of the bearing type and the bearing layout in a continuous structure is an important task, which shall be established during the initial design process itself. The layout of the bearings shall correspond to the structural analysis of the whole structure. The expected bearing movements and rotations shall be determined taking into account the sequence of construction. In case of stage by stage construction, stability of the partially completed unit shall be ensured by suitable means, which shall be clearly spelt out by the designer in the working drawings. Some of the typical layout of bearings for various forms of continuous structures are as shown in Figs. 3, 4 and 5.

a) The layout of cover for straight continuous girders, curved continuous structures - Fig. 4 and skewed continuous structures are shwon in Figs. 3,4 & 5 respectively.

The arrangement shown in the Fig. 3, 4 and 5 are only indicative and any other layout / arrangement of bearings can also be adopted. Methods of analysis, shall take into account the bearing orientations to determine the bearing movements and corresponding forces transferred to the substructure.

**5.3.2.** The horizontal earthquake forces that are being transferred through the fixed bearing in a continuous bridge is usually large. There is a concentration of stress at the joint and suitable tie back reinforcement may be necessary at the junction of fixed bearing with deck. Additional reinforcement may be required to be provided

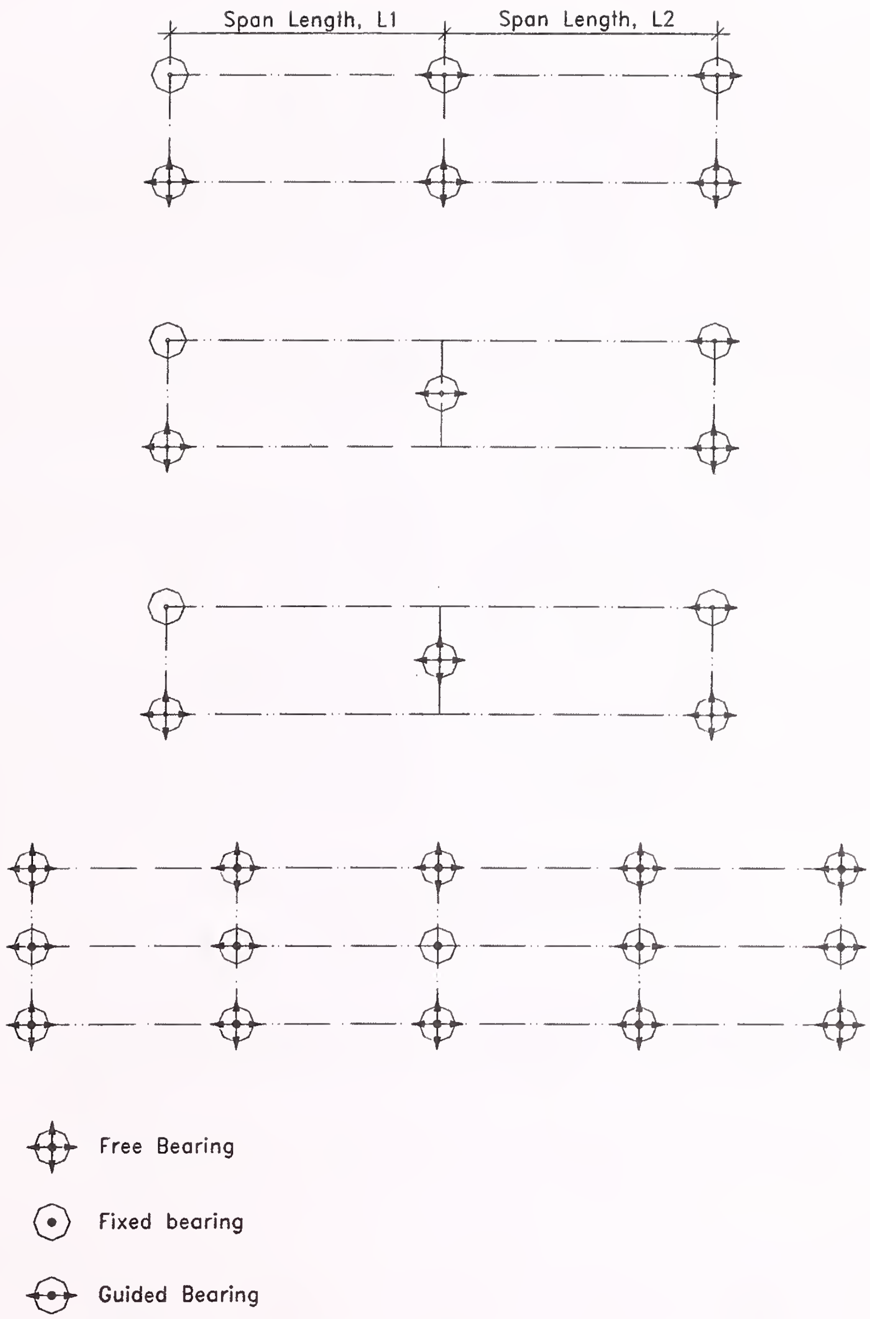



Fig. 3. Typical Bearing Layouts for Straight Continuous Bridges

within the influence width, in concrete adjoining the fixed bearing, which shall be designed to resist the horizontal force that is transferred through the bearings. These reinforcements shall be of length sufficient to ensure proper transfer of force. Fig. 6 shows a typical detail of such reinforcement.

**5.3.3.** When couplers are used for extending prestressing cables, not more than 50 per cent of the longitudinal post tensioning tendons shall be coupled at any one section [3].

## 6. BRIDGES MADE CONTINUOUS THROUGH DECK SLAB

For bridges made continuous through deck slab, two generic type of connections normally adopted for different situations are as described below:

**Type 1: Continuous separated deck slab** in which the deck slab is continued monolithically over the intermediate piers, without continuing the

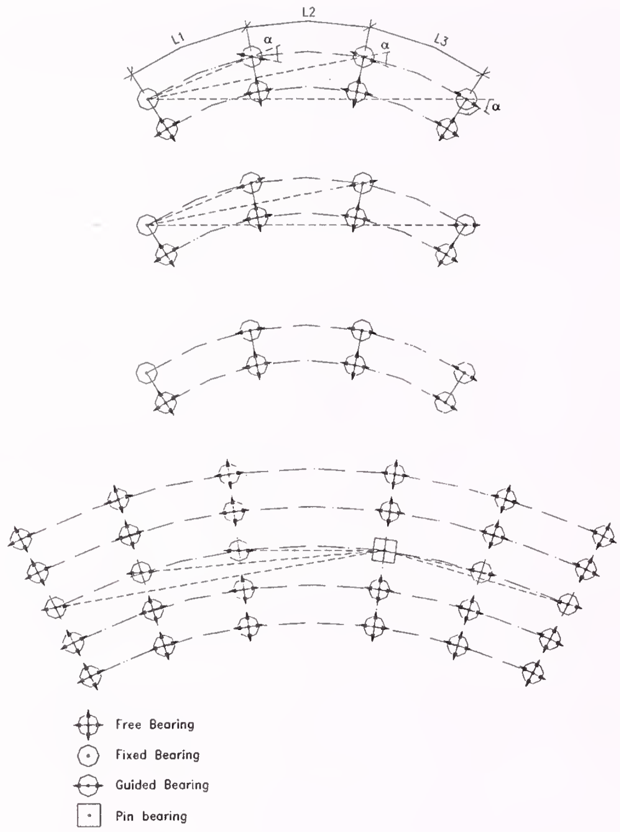



Fig. 4. Typical Bearing Layouts for Curved Continuous Bridges

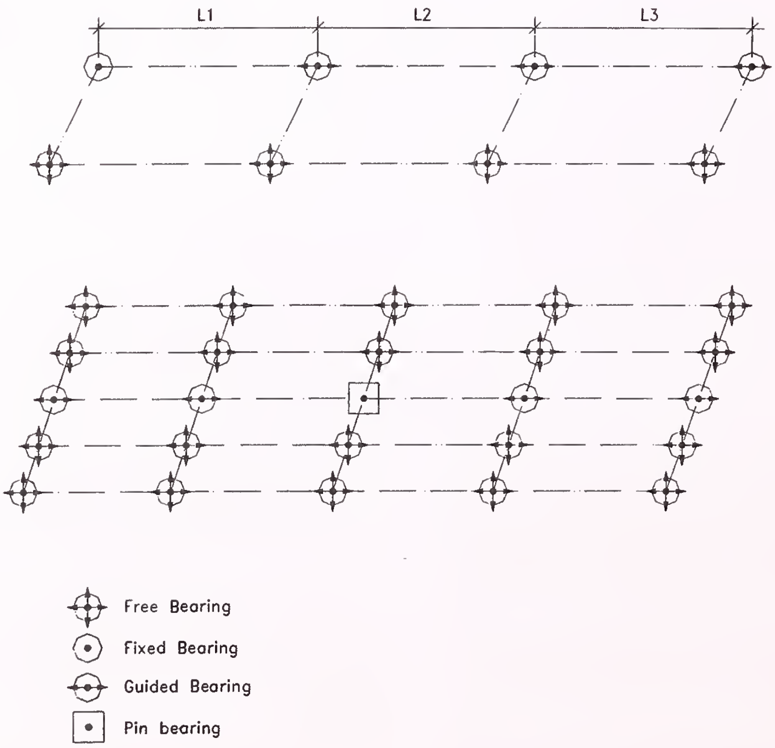



Fig. 5. Typical Bearing Layouts for Skewed Continuous Bridges

girders. The length of the separated deck slab between the girders shall be sufficient to provide both short-term and long-term flexibility required to accommodate rotation of the girders.[4] (Fig. 7a & Fig. 7b).

This type of connection is simple in design and construction. However it does not provide moment continuity at the supports.

**Type 2 : Tied deck slab** in which the deck slab is hinged over the pier using partly debonded dowelling (Fig. 8).

This type of detailing is applicable for short to medium span lengths and is aimed at minimising the number of expansion joints and improving riding quality. However the tied deck joint retains the rotational capacity, with a sealed notch provided in the deck surfacing.

It should be noted that bridges made continuous through deck slab do not provide moment continuity and thus in terms of structural action for vertical loads, the bridge can be considered as simply supported for the design of girders. Hence specific clauses pertaining to continuous structure do not apply for these bridges. For lateral loads however, the bridge is to be treated as continuous. The continuity slab over pier shall be designed for the forces arising out of the effect of such continuity, duly taking into account the effect of rotation of the girders subsequent to casting of the continuity slab. For the purpose of design of continuity slab, the permissible reduction in allowable stress in reinforcement shall be considered as 80 per cent to account for fatigue.

In case of bridges with deck continuity, the detailing of crash barrier for the continuity slab portion shall be done carefully. Gaps shall be left in crash barrier at the ends of continuity slab to allow for flexing of the slab.

## 7. REFERENCE

In this publication, reference to the following IRC, BS,AASHTO and Japan Road Association Standards has been made. At the time of

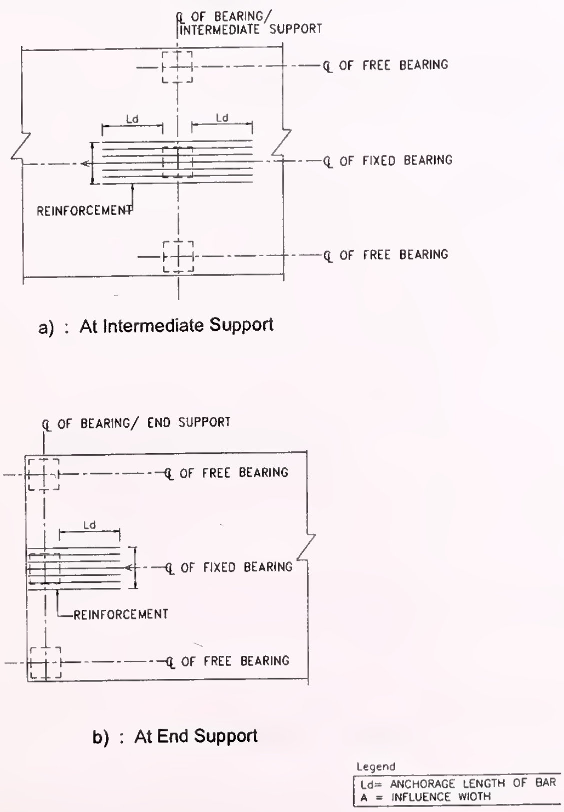



Fig. 6. Arrangement of Tie Back Reinforcement at Fixed Bearing

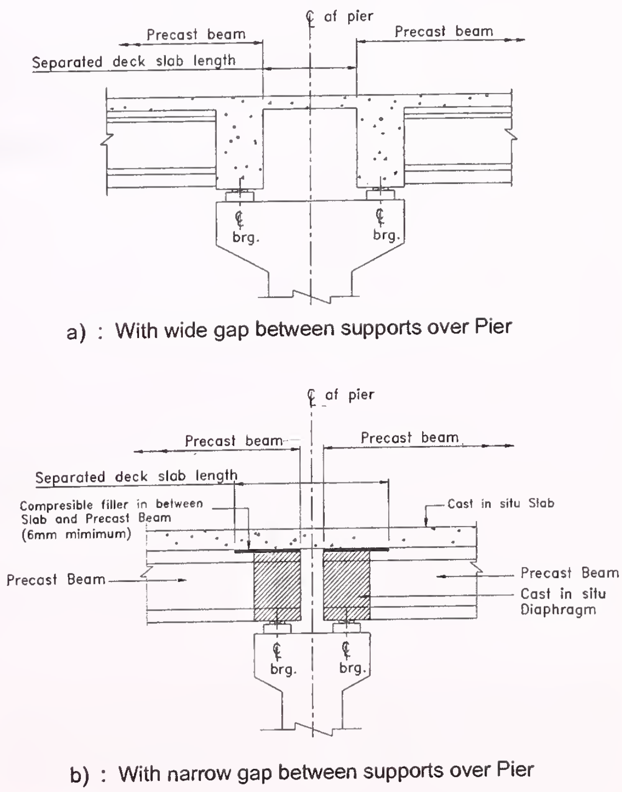



Fig. 7. Connection Type 1 : Continuous separated Deck Slab

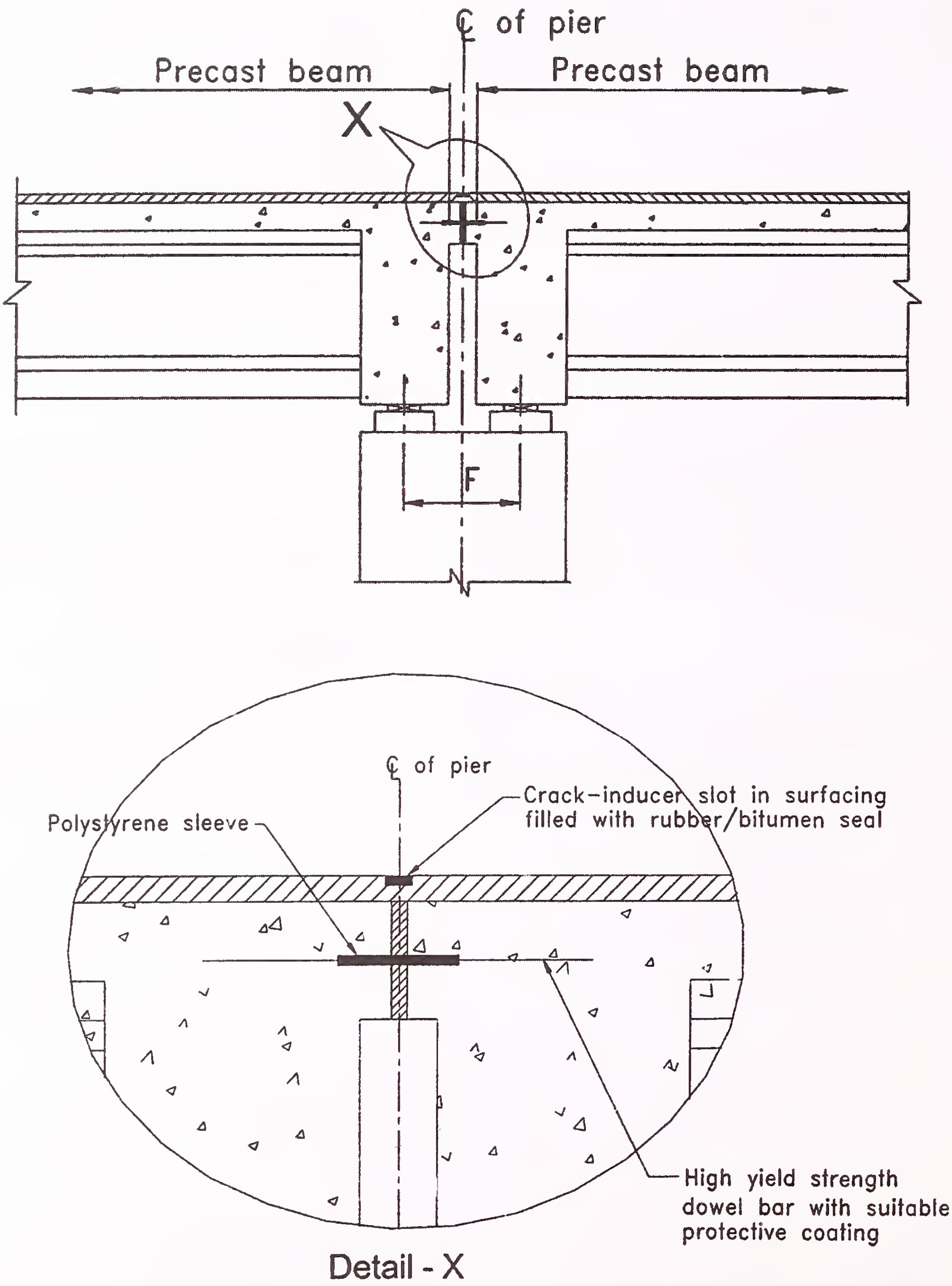



Fig. 8. Connection Type 2 : Tied Deck Slab

publication, the editions indicated were valid. All standards are subject to revision and the parties to agreements based on these guidelines are encouraged to investigate the possibility of applying the most recent editions of Standards.

**7.1 Codes & Specifications**

1. IRC:6-2000 Standard Specifications and Code of Practice for Road Bridges, Section II-Loads and Stresses (Fourth Revision)

**2.** IRC:18-2000 Design Criteria for Prestressed Concrete Road Bridges (Post Tensioned Concrete) (Third Revision)

**3.** IRC:21-2000 Standard Specifications and Code of Practice for Road Bridges Section III Cement Concrete (Plain and Reinforced) (Third Revision)

**4.** BS 5400:Part 4: Code of Practice for 1984 Design of Concrete Bridges

**5.** AASHTO LRFD Bridge Design Specifications: 1999 Interim

**6.** Japan Road Specification for Association Highway Bridges


**7.2. Papers & Publications**


1. Brain Pitchard 'Bridge Design for Economy be Durability-Concept for New, Strengthened and Replacement of Bridges.

2. Gunter Ramberger 'Structural Bearings and Expansion Joints for Bridges' SE6 IABSE Zurich.

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